

A Radio Detector System for Ultra High Energy Cosmic Showers Study

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1. Introduction

The nature and origin of Ultra High Energy (UHE) cosmic rays ($E \geq 10^{17}$ eV) are still not understood. Large detector arrays now in operation (e.g. AGASA[1]) and in construction (AUGER[2]) extend the detection capabilities to the energies of 10^{19} eV and beyond. It is now clear that events beyond the GZK (Greisen-Zatsepin-Kuz'min) limit of 10^{19} eV can be detected [3]. The interaction of UHE cosmic rays with the atmosphere can also permit the study of exotic physical phenomena, such as extra dimensions and production of mini black-holes [4].

The event rate for such UHE cosmic rays is, however, quite small (1 events per square kilometer per year for $E = 10^{18}$ eV). To acquire events at a reasonable rate, conventional large detector arrays are an expensive option. It has been suggested that the use of triggered radars and radio detection from showers could be an alternative technique[5]. The difficulty with this approach is that the proposed systems depends on long ionization lifetime, which may not be the case for UHE shower events.

We explore a technique that employs a bistatic passive CW radar system. Such radar is tuned to the lower VHF frequencies to acquire the signals reflected from the ionization clouds produced by UHE showers and burning meteors in the atmosphere.

2. The Experimental Setup

The setup proposed is composed of a few radio detection stations. Each station is composed of a set of antennas and data acquisition systems. The signals from these antennas are preprocessed by computer-controlled radio receivers which demodulate the reflected signal, downshifting their frequency to a limited band (2.8 KHz). The signal is then digitized and stored by a computer. The spectrogram of the signal is displayed while data is being recorded. In order to synchronize data from different sites, a GPS clock is used. This allows for offline data correlations.

The current data acquisition is built around an 8 channels high performance audio card. This card can sample data at a rate of 48 KHz, providing detailed information on the signal waveform. However, we are considering the possibility of using digital radio for data collection. A complete software for data acquisition and time-stamping through the GPS server has been designed. A tool for offline data analysis is also being prepared for automatic scanning of acquired data.

3. Preliminary Results

One out of the three radio stations is now operational at BNL. Its three radio receivers are set to the frequencies of 55.24 MHz and 67.26 MHz (2) Different sampling rates were used in order to test the system performance, reaching a maximum of 48 KHz in the three channels.

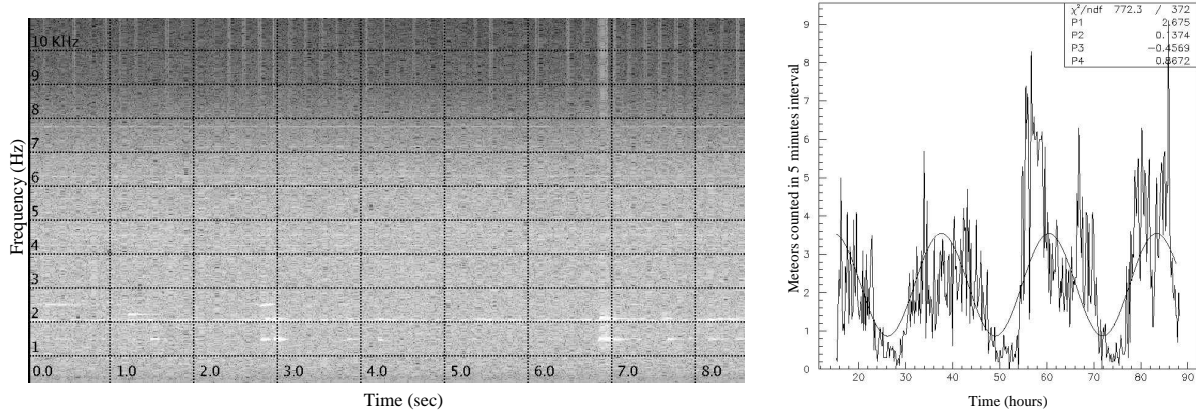


Figure 1. Meteor event registered by the Radio Detection System in a frequency-time spectrogram (left). Meteor counting during a period of three days (right).

Figure 1 (left) displays the online spectrogram of the data acquisition software. The gray tone scale gives the power in dB at each frequency-time point (light colors meaning higher values).

As can be seen, there is a clear signal (two light marks) above the noise level around 6.9 seconds and 1-2 KHz. Due to the duration of this signal (more than 0.2 s.), it was considered as coming from a meteor. An automatic scheme has been developed to count the number of meteors (and possible particle shower events) during some fixed time intervals. The figure at the right shows the count number in one of the channels (a given Log-Periodic antenna at 55.24 MHz) during 3 days. Each point represents 5 minutes of acquisition. A 24 hours periodicity is observed and it is consistent with previously readout data [6].

4. Summary

A Radio Detection System for UHE cosmic showers is discussed. The implementation using antennas, radio receivers and GPS clock is proposed as an alternative technique to increase the effective detector area. Preliminary results show that the system is sensitive to meteors and possible particle showers. A large amount of data (24 GB) was acquired until now and further analysis are being performed on such data.

In order to confirm shower detection and prove the system effectiveness, muon detector arrays will be installed in high schools on Long Island.

REFERENCES

1. Hayashida *et al.* *Phys. Rev. Let.* V. 73. pp. 3491 (1994).
2. Dova, M.T. "Survey of the Pierre Auger Observatory". *Proceedings of ICRC* pp. 699 (2001).
3. Takeda, M. *et al.* "Extension of the Cosmic-Ray Energy Spectrum beyond the Predicted Greisen-Zatsepin-Kuz'min Cutoff". *Phys. Rev. Let.* V. 81-6 (1998).
4. Feng, J.L., Shapere, A.D. "Black Hole Production by Cosmic Rays". *Phys. Rev. Let.* V. 88-2 (2002).
5. Gorham, P. "On the Possibility of Radar Echo Detection of Ultra High Energy Cosmic Ray and Neutrino Induced Extensive Air Showers". *Astropart. Phys.* V. 15. pp. 177 (2001).
6. Janches, D., Mathews, J.D., Meisel, D.D. and Zhou, Q.-H. "Micrometeor Observations Using the Arecibo 430 MHz Radar". *Icarus.* V. 145. pp. 53 (2000).